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CLAIMS

1. A method of operating a CDMA cellular communications system comprising at least one macro cell having a macro cell base station and at least one micro cell having a micro cell base station, at least part of the micro cell being located within an area served by the macro cell base station, separate frequency bands normally required for simultaneous communication of data from said macro cell and micro cell base stations, which method comprises the steps of:

(1) receiving an electronic indication representative of the quality of service at one or more cellular communications device served by the macro cell base station;

(2) electronically processing the or each electronic indication to obtain a comparison with a predetermined threshold for said quality of service; and

(3) maintaining said quality of service above said predetermined threshold for any cellular communications device(s) served by the macro cell base station that is within a predetermined range of the micro cell base station by limiting the power of signals transmitted from the micro cell base station, whereby data may be transmitted and received in the micro and macro cells on substantially the same CDMA frequency band(s).

2. A method as claimed in claim 1, wherein those cellular communications device(s) within said predetermined range can be determined by electronically processing signals representative of macro cell interference and micro cell interference at each cellular communications device, the predetermined range being that distance at which micro cell interference is negligible in comparison with macro cell interference.

3. A method as claimed in claim 1 or 2, wherein said predetermined range is that distance from the micro cell base station at which micro cell interference is at least approximately 10dB less than macro cell interference.

4. A method as claimed in claim 1, 2 or 3, further comprising the steps of generating an electronic signal representative of said predetermined range, receiving respective electronic signals representative of the distance between said micro cell base station and the or each cellular communications device served by the macro cell,

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and processing said electronic signals so as to determine those cellular communications devices served by the macro cell that are within said predetermined range.

5. A method as claimed in claim 4, wherein said electronic signals representative of the distance between said micro cell base station and the or each cellular communications device are obtained by the steps of determining a respective estimated geographic position of the or each cellular communications device and processing said estimated geographic position to determine a distance between said micro cell base station and the or each cellular communication device.

6. A method as claimed in claim 6, further comprising the step of obtaining said respective estimated geographic position of the or each cellular communications device with a radiolocation method.

7. A method as claimed in any preceding claim, wherein the step (3) is carried out by electronically determining a tolerable micro cell base station power level for the or each cellular communications device served by the macro cell base station and instructing said micro cell base station to transmit all signals at a power substantially no higher than said tolerable level.

8. A method as claimed in claim 7, further comprising the steps of electronically determining a tolerable micro cell base station power level for all cellular communications devices served by the macro cell base station within said predetermined range, and electronically instructing said micro cell base station to transmit signals at a power substantially no higher than the lowest tolerable micro cell base station power that has been determined for said cellular communications devices.

9. A method as claimed in claim 7 or 8, wherein said tolerable micro cell base station power level is a fraction of the power of signals from the macro cell base station.

10. A method as claimed in claim 9, wherein for each cellular communications device said tolerable micro cell base station power is obtainable by from: -

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$$P_{MIC}^{MAX} = P_{MAC} \cdot \frac{L_{MAC}}{L_{MIC}} \left[\frac{1}{SINR_{MIN}} - \frac{1}{SINR_0} \right]$$

where P_{MIC}^{MAX} is the maximum tolerable micro cell base station power, P_{MAC} is the transmitted power from the macro cell base station, L_{MAC} and L_{MIC} are the path loss from the macro cell and micro cell base stations respectively, $SINR_{MIN}$ corresponds to the minimum tolerable signal to interference plus noise ratio for each cellular communications device, and $SINR_0$ is the signal to interference plus noise ratio of the cellular communications device assuming there is no micro cell base station interference.

11. A method as claimed in any preceding claim, further comprising the step of electronically determining a residence time in said predetermined range for the or each cellular communications device served by the macro cell base station, said residence time being useable to substantially maintain the quality of service of said cellular communications device(s).

12. A method as claimed in any preceding claim, further comprising the step of substantially ceasing transmission of signals from said micro cell base station to cellular communications device(s) served thereby in order to substantially maintain the quality of service of cellular communications devices served by the macro cell base station that are within said predetermined range.

13. A method as claimed in claim 11 or 12, further comprising the step of electronically instructing said micro cell base station to take over service of the or each cellular communications device within said predetermined range, enabling resumption or continuation of transmission and reception of signals to and from cellular communications devices served by the micro cell base station and/or macro cell base station.

14. A method as claimed in claim 13, further comprising the step of prioritising service from said micro cell base station to cellular communications devices requiring substantially real-time data above those requiring substantially non-real-

time data.

15. A method as claimed in any preceding claim, further comprising the step of serving cellular communications device(s) from said macro cell base station with at least one adaptive antenna capable of directional transmission and/or reception, thereby enabling reduction in the necessary transmission power of said micro cell base station and cellular communications devices served thereby to achieve a given signal quality.

16. A method as claimed in any preceding claim, further comprising the step of electronically adjusting the data transmission rate to cellular communications devices served by the micro cell base station.

17. A method as claimed in claim 16, further comprising the steps of electronically processing said electronic indication and a selected data transmission rate for each cellular communications device to determine a proportion of the maximum tolerable micro cell base station power for that cellular communications device, until either all of said available micro cell base station power has been assigned or the total number of cellular communications devices been processed, prioritising assignment of transmission power to cellular communications device(s) requiring substantially real-time data above those requiring substantially non-real-time data, and transmitting data to each cellular communications device at the respective assigned transmission power.

18. A method as claimed in claim 17, wherein said proportion for the *i*th cellular communications device is obtainable from: -

$$\phi_i = \frac{(SINR)_i R_i (I_{inter} + I_{intra} + I_{inter-l} + N_0)}{\beta P C}$$

assuming the Gaussian approximation for multiple access interference, and where $SINR_i$ is the signal to interference plus noise ratio, R is the transmission rate from the micro cell base station, I_{inter}, I_{intra} and $I_{inter-l}$ are inter-cell, intra-cell and inter-layer interference components respectively, N_0 is noise, β is the user's path loss factor in real terms (not in dB), P is the total output power from the micro cell base

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station, C is the constant chip rate and where $0 \leq \phi_i \leq 1$.

19. A method as claimed in claim 17 or 18, further comprising the step of electronically adjusting said selected data transmission rate if said electronic processing determines said proportion to be such that, on its own or when summed with proportion(s) calculated for any other cellular communications device(s), it exceeds said maximum tolerable micro base station transmission power, and re-performing said electronic calculation with said adjusted selected data rate.

20. A method as claimed in any preceding claim, further comprising the steps of electronically instructing buffering of data for cellular communications devices served by the micro cell base station, and adjusting the number of those cellular communications devices to which data is transmitted to increase the ability of the system to serve the remaining cellular communications devices being served by the micro cell base station.

21. Computer operable control means for use with a CDMA cellular communications system comprising at least one macro cell having a macro cell base station and at least one micro cell having a micro cell base station, at least part of the micro cell being located within an area served by the macro cell base station, separate frequency bands normally required for simultaneous communication of data from said macro cell and micro cell base stations, the computer operable control means comprising:

means for receiving an electronic indication representative of the quality of service at one or more cellular communications devices served by the macro cell base station;

means for electronically processing the or each electronic indication to obtain a comparison with a predetermined threshold for said quality of service; and

means for maintaining said quality of service above said predetermined threshold for any cellular communication device(s) served by the macro cell base station that is within a predetermined range of the micro cell base station by limiting the power of signals transmitted from the microcell base station, whereby data may be the transmitted and received in the micro and macro cells on substantially the same CDMA frequency bands.

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22. Computer operable control means as claimed in claim 21, further comprising means for determining those cellular communications device(s) within said predetermined range by electronically processing signals representative of macro cell interference and micro cell interference at said cellular communications device(s), the predetermined range being that distance at which micro cell interference is negligible in comparison with macro cell interference.

23. Computer operable control means as claimed in claim 22, wherein said predetermined range is that distance from the micro cell base station at which micro cell interference is at least approximately 10dB less than macro cell interference.

24. Computer operable control means as claimed in claim 21, 22 or 23, further comprising means for generating an electronic signal representative of said predetermined range, generating respective electronic signals representative of the distance between said micro cell base station and the or each cellular communications device served by the macro cell, and means for processing said electronic signals so as to determine those cellular communications devices served by the macro cell that are within said predetermined range.

25. Computer operable control means as claimed in claim 24, wherein said means for generating electronic signals representative of the distance between said micro cell base station and the or each cellular communications device can receive an electronic signal representative of a respective estimated geographic position of the or each cellular communications device and can process said signal to determine a distance between said micro cell base station and the or each cellular communication device.

26. Computer operable control means as claimed in claim 25, further comprising means for obtaining said respective estimated geographic position of the or each cellular communications device by a radiolocation method.

27. Computer operable control means as claimed in any of claims 21 to 26, further comprising means for determining a tolerable micro cell base station power level for the or each cellular communications device served by the macro cell base station and means for instructing said micro cell base station to transmit all signals at

a power substantially no higher than said tolerable level.

28. Computer operable control means as claimed in claim 27, further comprising means for determining a tolerable micro cell base station power level for all cellular communications devices served by the macro cell base station within said predetermined range, and means for instructing said micro cell base station to transmit signals at a power substantially no higher than the lowest tolerable micro cell base station power that has been determined for said cellular communications devices.

29. Computer operable control means as claimed in claim 27 or 28, wherein said means for determining a tolerable micro cell base station power level can, in use, determine said tolerable micro cell base station power as a fraction of the power of signals from the macro cell base station.

30. Computer operable control means as claimed in claim 29, wherein for each cellular communications device said tolerable micro cell base station power is obtainable by from: -

$$P_{MIC}^{MAX} = P_{MAC} \cdot \frac{L_{MAC}}{L_{MIC}} \left[\frac{1}{SINR_{MIN}} - \frac{1}{SINR_0} \right]$$

where P_{MIC}^{MAX} is the maximum tolerable micro cell base station power, P_{MAC} is the transmitted power from the macro cell base station, L_{MAC} and L_{MIC} are the path loss from the macro cell and micro cell base stations respectively, $SINR_{MIN}$ corresponds to the minimum tolerable signal to interference plus noise ratio for each cellular communications device, and $SINR_0$ is the signal to interference plus noise ratio of the cellular communications device assuming there is no micro cell base station interference.

31. Computer operable control means as claimed in any of claims 21 to 30, further comprising means for determining a residence time in said predetermined range for the or each cellular communications device served by the macro cell base station, said residence time being useable to substantially maintain the quality of

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service of said cellular communications device(s).

32. Computer operable control means as claimed in any of claims 20 to 31, further comprising means for ceasing transmission of signals from said micro cell base station to cellular communications device(s) served thereby to substantially maintain the quality of service of cellular communications devices served by the macro cell base station and/or micro cell base station.

33. Computer operable control means as claimed in claim 30 or 32, further comprising means for instructing said micro cell base station to take over service of the or each cellular communications device within said predetermined range, enabling resumption or continuation of transmission and reception of signals to and from cellular communications devices served by the micro cell base station.

34. A method as claimed in claim 13, further comprising the step of prioritising service from said micro cell base station to cellular communications devices requiring substantially real-time data above those requiring substantially non-real-time data.

35. Computer operable control means as claimed in any of claims 31 to 34, further comprising means for controlling at least one adaptive antenna capable of directional transmission and/or reception, thereby enabling reduction in the necessary transmission power of said micro cell base station and cellular communications devices served thereby to achieve a given signal quality.

36. Computer operable control means as claimed in any of claims 21 to 35, further comprising means for adjusting the data transmission rate to cellular communication devices served by the micro cell base station.

37. Computer operable control means as claimed in claim 36, further comprising means for electronically processing said electronic indication and a selected data transmission rate for each cellular communications device to determine a proportion of the maximum tolerable micro cell base station power for that cellular communications device, until either all of said available micro cell base station power has been assigned or the total number of cellular communications devices been

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processed, means for prioritising assignment of transmission power to cellular communications device(s) requiring substantially real-time data above those requiring substantially non-real-time data, and means for instructing transmission of data to each cellular communications device at the respective assigned transmission power.

38. Computer operable control means as claimed in claim 37, wherein said proportion for the *i*th cellular communications device is obtainable from: -

$$\phi_i = \frac{(SINR)_i R_i (I_{inter} + I_{intra} + I_{inter_L} + N_0)}{\beta PC}$$

assuming the Gaussian approximation for multiple access interference, and where $SINR_i$ is the signal to interference plus noise ratio, R is the transmission rate from the micro cell base station, I_{inter}, I_{intra} and I_{inter_L} are inter-cell, intra-cell and inter-layer interference components respectively, N_0 is noise, β is the user's path loss factor in real terms (not in dB), P is the total output power from the micro cell base station, C is the constant chip rate and where $0 \leq \phi_i \leq 1$.

39. Computer operable control means as claimed in claim 37 or 38, further comprising means for electronically adjusting said selected data transmission rate if said electronic processing determines said proportion to be such that, on its own or when summed with proportion(s) calculated for any other cellular communications device(s), it exceeds said maximum tolerable micro base station transmission power, and means for re-performing said electronic calculation with said adjusted data rate.

40. Computer operable control means as claimed in any of claims 21 to 39, further comprising means for buffering data for cellular communications devices served by the micro cell base station, and means for adjusting the number of those cellular communications devices to which data is transmitted to increase the ability of the system to serve the remaining cellular communications devices being served by the micro cell base station.

41. A base station controller comprising a computer operable control means as claimed in any of claims 21 to 40.

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42. A computer readable medium storing computer executable instructions for carrying out a method according to any of claims 1 to 20.

43. A computer program comprising program instructions for causing a computer, for example a base station controller, to carry out the method of any of claims 1 to 20.

44. A computer program comprising program instructions for causing a computer, for example a macro cell base station controller, to perform the method steps of any of claims 1 to 13.

45. A computer program comprising program instructions for causing a computer, for example a micro cell base station controller, to perform the method steps of any of claims 11 to 20.

46. A CDMA communications system comprising computer operable control means as claimed in any of claims 21 to 40, at least one macro cell base station, and at least one micro cell base station having at least a part of the micro cell within the area served by said macro cell base station, said CDMA communications system being operable in accordance with a method as claimed in any of claims 1 to 20.

47. A method of operating a cellular communications system comprising at least one macro cell having a macro cell base station and at least one micro cell having a micro cell base station, at least part of the micro cell being located within an area served by the macro cell base station, which method comprises the steps of prioritising transmission of data to a first group of cellular communications devices served by the micro cell base station that require substantially real-time data above a second group of cellular communications devices that require substantially non-real-time data, by assigning a fraction of available micro cell base station power to each cellular communications device based on the signal to interference plus noise ratio of each device, starting with those in said first group, either until all of said available micro cell base station power is assigned or until all of said cellular communication devices have been assigned a fraction; and transmitting data to said first and/or second groups of cellular communications devices based on said fractions.

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48. A method as claimed in claim 46, wherein said fraction for the *i*th cellular communications device is obtainable from: -

$$\phi_i = \frac{(SINR)_i R_i (I_{inter} + I_{intra} + I_{interL} + N_0)}{\beta PC}$$

assuming the Gaussian approximation for multiple access interference, and where $SINR_i$ is the signal to interference plus noise ratio, R is the transmission rate from the micro cell base station, I_{inter}, I_{intra} and I_{interL} are inter-cell, intra-cell and inter-layer interference components respectively, N_0 is noise, β is the user's path loss factor in real terms (not in dB), P is the total output power from the micro cell base station, C is the constant chip rate and where $0 \leq \phi_i \leq 1$.